Moss Landing Marine Laboratories

Technical Publication 72-5

TIDAL OSCILLATIONS AT THE HEAD OF MONTEREY SUBMARINE CANYON AND THEIR RELATION TO OCEANOGRAPHIC SAMPLING AND THE CIRCULATION OF WATER IN MONTEREY BAY

Annual Report, Part 6, September 1972

by

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Moss Landing Marine Laboratories
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ABSTRACT

During a 25-hour hydrographic times series at two stations near the head of Monterey Submarine Canyon, an internal tide was observed with an amplitude of 80 to 115 m in water depths of 120 and 220 m respectively. These large oscillations produced daily variations in hydrographic and chemical parameters that were of the same magnitude as seasonal variations in Monterey Bay. Computed velocities associated with the internal tide were on the order of 10 cm/sec, and this tidally induced circulation may have a significant role in the exchange of deep water between Monterey Submarine Canyon and the open ocean.

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INTRODUCTION

During our monthly oceanographic surveys of Monterey Bay in 1971 (Broenkow 1972), it became apparent that large, short term changes occurred in the vertical distributions of physical and chemical parameters in the area of Monterey Submarine Canyon. The primary objective of our monthly surveys was to determine the seasonal and relatively small scale spatial variations of properties within Monterey Bay. From these observations, it was hoped to delineate circulation patterns and to determine the residence time of water parcels in the inner bay.

Preliminary analysis of the data for the first 6 months of 1971 showed that during some periods of apparently strong upwelling, temperature, salinity and related isopleths appeared to slope downward toward shore along the axis of Monterey Submarine Canyon: the opposite of what would be expected. Because tidally modulated currents have been observed in the canyon, (Gatje and Pizinger 1965; Njus 1968; Caster 1969), it was suggested that the apparently anomalous vertical distributions of properties might be caused by non-synoptic measurements.

Within 10 km of the head of the canyon in depths between 100 and 400 m, bottom currents are aligned predominently along the canyon axis with current speeds varying from zero to about 50 cm/sec (Gatje and

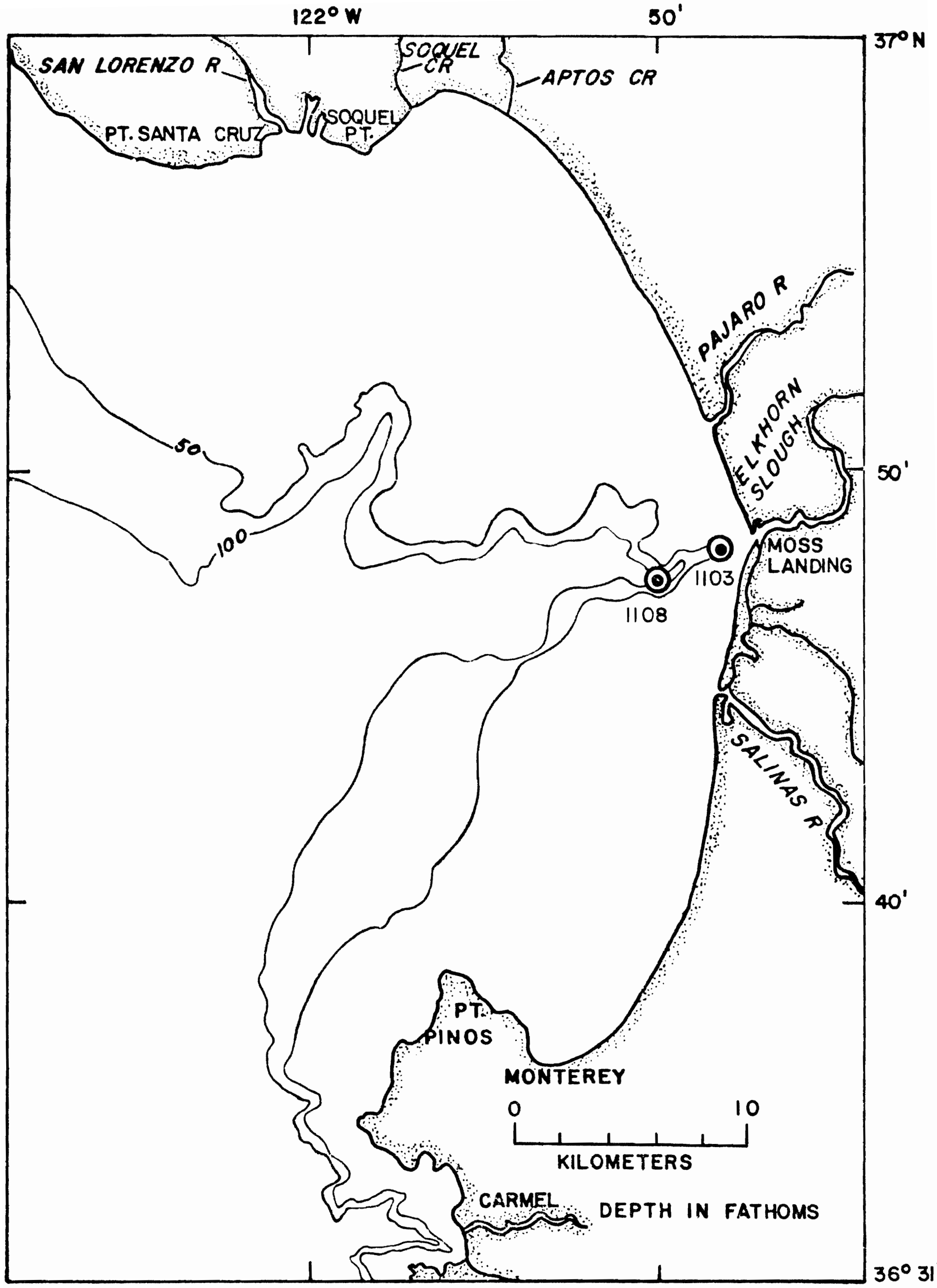

Figure 1. Monterey Bay station locations, Cruise 14, 7-8 August 1971. Depth contours in fathoms.

Pizinger 1965; Njus 1968; Caster 1969). Both long and short period velocity fluctuations have been recorded, but the only recognizable driving force was tidal. No inertial periods were found, and spectral peaks shorter than 12 hours were thought to have been associated with internal waves. Thirty minute periods associated with a seiche in Monterey Bay (Ranines 1967; Robinson 1969) have not been identified in the near-bottom velocity records. In some instances, however, accelerations of about 0.5 cm/sec^2 have been observed for periods of a few minutes.

Median near-bottom current speeds of about 10 cm/sec at 130 m in Monterey Submarine Canyon near station 1103 were recorded by Gatje and Pizinger (1965) and by Dooley (1968). Similar speeds were observed approximately 4 km offshore of our station 1108 at depths of 366 m (Custer 1969). These investigators observed generally up-canyon flow accompanied by decreasing temperatures during periods of falling tides and the opposite during rising tides. Gatje and Pizinger (1965) suggest that a net down-canyon flow of about 1 cm/sec may exist because of wind-driven convergence of near-surface waters in central Monterey Bay. Other investigators (Shepard et al 1939; Shepard et al 1964) have not observed the strong relation in between deep currents and tides in California submarine canyons, but Stetson (1937) has observed this tide-current relation in Georges Bank Canyons.

The above current studies have not shown whether or not the observed flow was a boundary layer phenomonon or whether the tidal flow extended throughout the water column. To determine the extent to which the distribution of properties are tidally modulated, a 24-hour hydrographic time series was conducted at two stations near the head of the canyon (Fig. 1) on 7 and 8 August 1971. During this period, stations 1103 and 1108 were each occupied 10 times at approximately 2.5 hour intervals.

ACKNOWLEDGMENTS

We wish to thank the following people who participated in ML Cruise 14: Sandra Benz, Patrick Clark, Judith Hansen, Gary Kukowski, David Seielstad, Dr. Mary Silver, Develyn Texeira, and David Ventresca. In addition we thank Sandra Benz, David Seielstad, Richard Smith, and David Ventresca for performing the laboratory analyses and Frank Monnich, the Captain of R/V Amigo.

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METHODS

Station positions were determined from radar ranges and fathometer readings. The accuracy of reoccupying the stations was better than ± 0.2 km, because exceptionally good weather was experienced. Four 5-liter Niskin plastic sampling bottles were used to obtain discrete water samples in 2 casts at the standard sampling depths, 0, 5, 10, 20, 30, 50, 75, 100 and 150 m. Accepted sampling depths were determined from wire angle for depths less than 100 m and from a combination of wire angle and thermometric depth calculations for depths greater than 100 m.

The *in situ* temperatures were determined from paired reversing thermometers, and the values were averaged when the thermometers agreed to within 0.05°C. Salinity was determined by means of a Beckman Model RS-7B precision induction salinometer. Analyses were made in the laboratory and salinity was computed from conductivity ratio using the equations of Cox, et al (1967). Substandard seawater was used to calibrate the salinometer before and after each set of 24 or fewer samples. Copenhagen water was used to standardize the substandard water.

Water samples were treated aboard ship to fix the oxygen in the basic form. The samples were acidified and titrated in the laboratory within 12 hours of the sampling time using Carpenter's (1965) modification of the Winkler method. The total sample was titrated with approximately 0.02 N sodium thiosulfate to the starch endpoint. Precision of the analyses is about ± 0.06 ml/liter (2 SD).

The 500 ml water samples for nutrient analyses were filtered through 3 μm glass fiber filters, quick frozen in a dry ice-alcohol solution aboard ship and refrigerated at -10°C until analyzed ashore within 3 weeks of collection. Groups of 36 samples were quick-thawed in the laboratory just prior to the analyses for phosphate, nitrate, ammonia, nitrite, and silicate. Standards and reagent blanks were prepared fresh daily and were determined with each set of samples.

Dissolved reactive phosphate was determined by the method of Murphy and Riley (1962) described in Strickland and Parsons (1968) using ascorbic acid to reduce the phospho-molybdate complex. The sample absorbance was determined in 10 cm cells on a Beckman DU 2 Spectrophotometer at 885 nm. Precision of the analyses is about ± 0.03 μg-atoms PO_4-P/liter (2 SD).

Nitrate was determined by the cadmium-reduction method of Wood _et al_ (1967) followed by the nitrite color development. The sample absorbance was determined in 1 cm cells using a Spectronic 20 Colorimeter at 543 nm. Precision of the analyses is about $\pm$ 0.5 μg-atoms NO_3-N/liter (2 SD).

Nitrite was determined by the method of Bendschneider and Robinson (1952) described by Strickland and Parsons (1967). The absorbance of the diazo color was determined on a Beckman DU using 10 cm cells at 543 nm. Precision of the method is about $\pm$ 0.03 μg-atoms NO_2-N/liter (2 SD).

Ammonia was determined by the indophenol method of Solorzano (1969) with the color absorbance determined with a Beckman DU at 640 nm using 10 cm cells. Precision of the method is about $\pm$ 0.1 μg-atoms NH_3-N/liter (2 SD).

Reactive silica was determined by the method of Mullin and Riley (1955) as modified by Strickland and Parsons (1968). The silicomolybdate complex was reduced by a metol-sulfite, oxalic acid solution, and the color absorbance was determined in 1 cm cells on a Spectronic 20 at 810 nm. Precision of the method is about $\pm$ 1 μg-atoms SiO_2-Si/liter (2 SD).

RESULTS AND CONCLUSIONS

The vertical and temporal variations in potential density anomaly (σ_T) (Figs. 2 and 3) show apparent tidal periodicity. These data are in agreement with the current meter observations of Gatje and Pizinger (1965), Dooley (1968), Njus (1968), and Caster (1969), and show the results of up-canyon flow during periods of falling tides and down-canyon flow during rising tides. Based on data obtained during limited duration drogue studies in southern Monterey Bay, Skogsberg (1936)

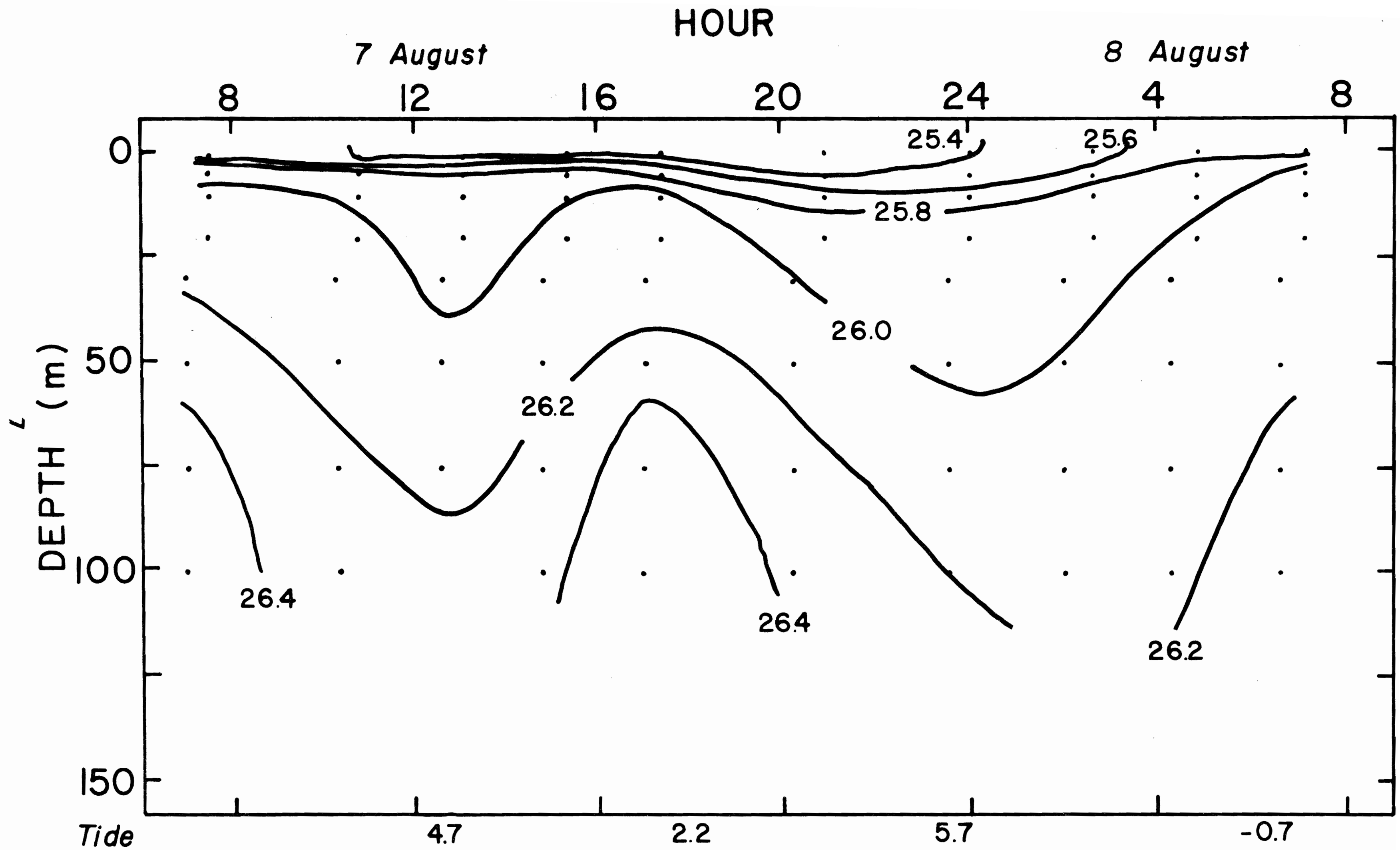

Figure 2. Distribution of σ_T , station 1103, 1 km west of Monterey Submarine Canyon head, Cruise 14, 7-8 August 1971. Depth contours in fathoms, predicted tidal height at Monterey in feet.

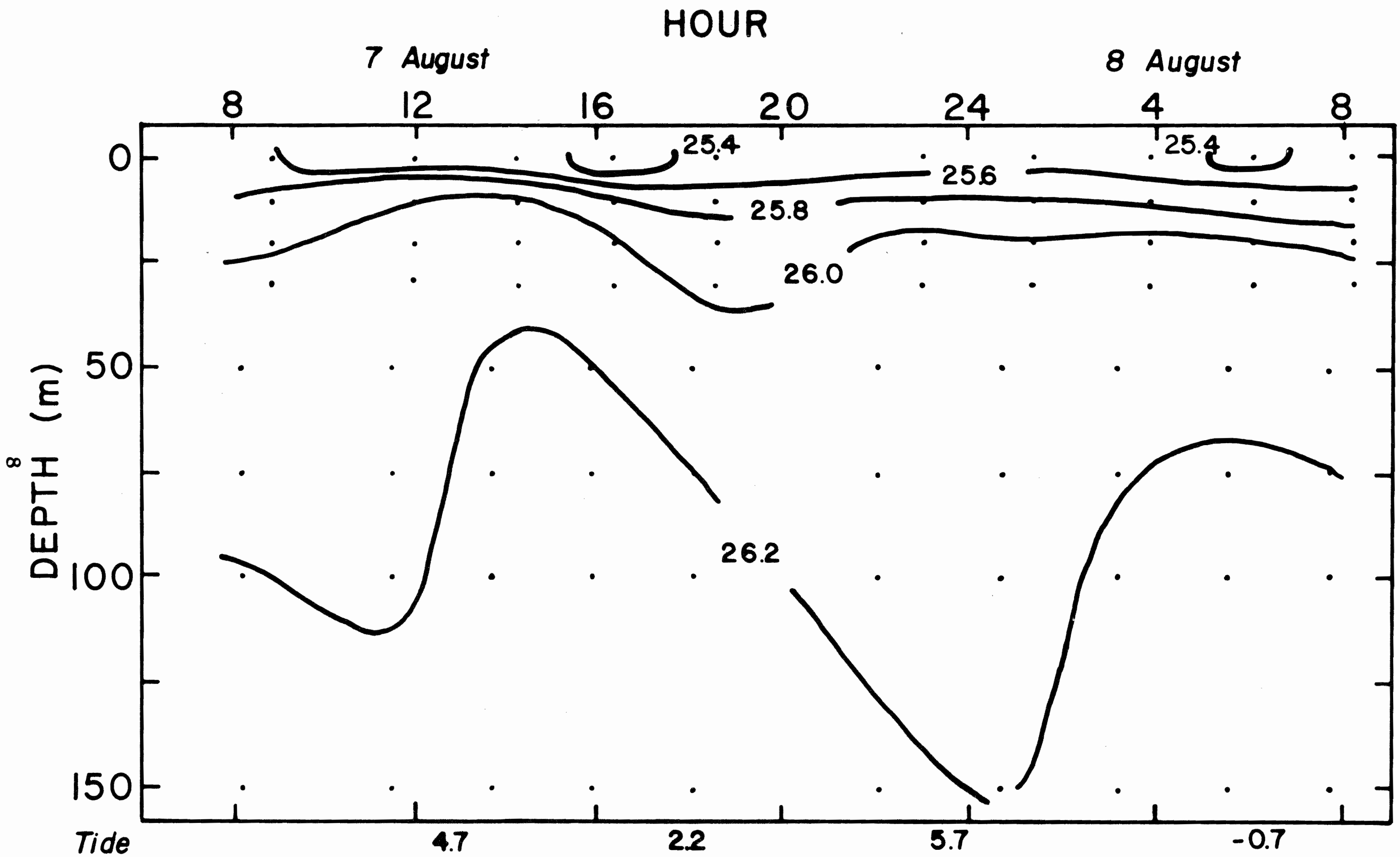

Figure 3. Distribution of σ_T, station 1108, 4 km west of Monterey Submarine Canyon head, Cruise 14, 7-8 August 1971. Depth contours in fathoms, predicted tidal height at Monterey in feet.

Table 1. Summary of observations at station 1103, 7-8 August 1971. Mean, high and low values are given for the n observations.

	DEPTH	TEMP	SALINITY	SIGMA T	OXYGEN	AOU	SAT	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
	m	^{o}C	ppt		ml/l	µg-at/l	%	µg-atoms/liter				
M	0	13.36	33.742	25.36	7.42	-149	129	.57	3.8	.16	.4	6
H		14.40	33.761	25.66	9.01	199	160	1.21	11.9	.33	1.1	19
L	n = 10	11.92	33.721	25.14	3.69	-31	62	.22	.9	.03	.0	1
M	5	11.50	33.782	25.75	6.05	-6	102	1.05	9.9	.31	.8	13
H		13.42	33.847	26.07	8.49	238	146	1.67	17.9	.63	1.6	27
L	n = 10	10.02	33.748	25.36	3.50	-238	57	.30	1.1	.06	.0	6
M	10	10.68	33.806	25.92	4.86	109	80	1.50	16.5	.42	1.1	18
H		12.22	33.876	26.16	7.99	265	136	2.19	23.1	.58	1.9	31
L	n = 10	9.64	33.768	25.61	3.25	-188	52	.36	7.1	.06	.0	2
M	20	10.12	33.834	26.02	3.83	208	62	1.86	19.6	.53	1.3	26
H		10.79	33.905	26.22	4.88	297	80	2.33	25.0	.72	2.2	35
L	n = 10	9.40	33.773	25.90	2.93	106	47	1.45	13.8	.39	.5	17
M	30	10.10	33.835	26.05	3.74	216	61	1.95	20.9	.58	1.4	26
H		10.76	33.885	26.15	4.81	273	79	2.40	25.1	1.23	2.2	33
L	n = 10	9.71	33.787	25.90	3.16	113	51	1.46	14.8	.37	.9	19
M	50	9.76	33.877	26.14	3.30	260	53	2.07	22.9	.49	1.2	30
H		10.62	33.983	26.37	4.38	348	72	2.64	28.3	.71	1.9	45
L	n = 9	8.82	33.803	25.93	2.27	153	36	1.63	16.8	.34	.4	22
M	75	9.36	33.917	26.22	2.81	309	45	2.20	25.1	.46	1.0	34
H		10.12	34.032	26.47	3.83	396	62	2.77	31.7	.63	1.9	48
L	n = 9	8.42	33.825	26.04	1.96	211	31	1.85	19.0	.29	.2	23
M	100	9.10	33.950	26.30	2.59	331	41	2.35	27.7	.46	.8	38
H		9.82	34.050	26.49	3.43	404	52	2.87	33.7	.56	1.8	53
L	n = 9	8.37	33.843	26.10	1.87	247	29	1.94	21.2	.32	.0	28

Table 2. Summary of observations at station 1108, 7-8 August 1971. Mean, high and low values are given for the n observations.

	DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU µg-at/l	SAT %	PHOSPHATE µg-atoms/liter	NITRATE µg-atoms/liter	NITRITE µg-atoms/liter	AMMONIA µg-atoms/liter	SILICA µg-atoms/liter
M	0	13.03	33.775	25.46	8.65	-255	150	.28	1.2	.08	.2	4
H		13.57	33.792	25.61	9.31	-67	163	.86	5.8	.25	.7	13
L	n = 10	12.18	33.754	25.33	6.65	-320	113	.12	.1	.02	.0	1
M	10	11.12	33.780	25.82	5.29	65	88	1.28	12.0	.34	.8	14
H		12.14	33.823	26.06	6.75	234	113	2.12	20.9	.61	1.8	28
L	n = 10	9.96	33.746	25.63	3.56	-71	58	.60	4.8	.09	.0	6
M	20	10.07	33.818	26.04	3.73	218	60	1.84	19.7	.52	1.2	26
H		10.89	33.852	26.13	5.09	268	70	2.29	23.1	.65	1.7	46
L	n = 10	9.68	33.757	25.85	3.22	86	52	1.37	13.9	.38	.5	14
M	30	9.89	33.836	26.07	3.51	239	57	1.98	21.7	.55	1.2	29
H		10.40	33.878	26.16	4.30	283	70	2.21	26.3	.66	1.6	38
L	n = 10	9.59	33.777	25.95	3.06	163	49	1.68	17.6	.47	.5	18
M	50	9.68	33.867	26.14	3.08	280	50	2.13	23.9	.60	1.1	31
H		10.06	33.927	26.23	3.66	319	59	2.42	26.1	.77	1.7	36
L	n = 10	9.40	33.826	26.05	2.68	224	43	1.81	17.7	.49	.7	27
M	75	9.50	33.901	26.20	2.83	305	45	2.22	26.2	.60	.6	33
H		9.76	33.943	26.28	3.19	341	51	2.49	31.4	.68	1.2	37
L	n = 9	9.16	33.863	26.11	2.47	269	39	1.89	23.9	.47	.0	28
M	100	9.16	33.938	26.28	2.54	334	48	2.27	26.8	.53	.4	36
H		9.62	34.022	26.45	3.04	391	49	2.53	29.7	.74	.9	41
L	n = 8	8.50	33.863	26.15	2.00	284	31	1.91	22.9	.29	.0	27
M	150	8.68	34.006	26.41	2.16	374	33	2.49	28.8	.41	.3	42
H		9.50	34.081	26.56	2.91	427	47	2.85	31.6	.65	.7	52
L	n = 8	8.10	33.892	26.19	1.66	297	26	2.17	20.8	.19	.0	17

suggested that the bottom waters moved into the bay during flooding tides, but from our data, it appears that the opposite is true in Monterey Submarine Canyon.

The maximum vertical displacement of isopycnals was about 80 m at station 1103 in 120 m depth and about 115 m at station 1108 where the water depth is about 220 m. The amplitude of the vertical oscillations was much larger than expected, more than 50% of the water depth at both stations. All observed parameters (Tables 1 and 2, Appendix) showed distributions similar to σ_T. These oscillations probably were internal tidal waves progressing shoreward. The phase lag between stations 1108 and 1103, a distance of about 3 km, was 3 to 4 hours thus indicating a wave velocity of about 20 to 30 cm/sec.

The widespread occurrence of internal waves of tidal period is well-documented (see, for example Defant 1961), and their presence in Monterey Submarine Canyon poses special sampling problems. When the depth of the isopleths varies so greatly, their apparent slope determined by conventional sampling methods may not correspond to the notion that during periods of upwelling the isopycnals should slope upward towards shore. On 7-8 August 1971 the apparent slope of the 26.2 σ_T surface between stations 1108 and 1103 would have varied from $+3 \times 10^{-2}$ to -2×10^{-2} depending upon the time at which each of these stations was occupied. Thus the apparent existence of sloping isopycnal surfaces within Monterey Submarine Canyon is not unambiguous evidence of upwelling. The average vertical distributions of σ_T over the 24 hour period (Tables 1 and 2) show insignificant differences between the depths of the isopycnals at stations 1103 and 1108. Thus, if average values are considered the isopycnals were essentially level. August 1971 was not a month during which strong upwelling occurred (W. Smethie, personal communication), and the lack of sloping isopycnals determined from the time averaged data agrees with this.

The time mean vertical distributions of selected parameters (Figs. 4 and 5) show that between 20 m and the surface the observed daily range in the parameters may be as large as 50 to 75% of the mean vertical variation in the water column. Note that the daily salinity range was smallest at the surface and greatest at depth, and that the daily dissolved oxygen range was greatest at the surface and decreased with depth (Fig. 4). Presumably this was due to the difference in behavior of conservative and nonconservative solutes and probably reflects the diel changes in the photosynthetic oxygen production in the near-surface water. Tidal variability in the water above 20 m was not entirely absent. This and lateral flow across the canyon and from Elkhorn Slough mask any obvious diel variations in the nonconservative parameters resulting from photosynthetic and respiration processes. Smethie (personal communication) determined the 0-10 m average values of selected parameters in Monterey Submarine Canyon between February 1971 and May 1972. These seasonal ranges (Table 3) are comparable to the daily ranges observed at the head of the canyon (Tables 1 and 2). The total amplitude of the thermal variation at the surface in southern Monterey Bay reported by Skogsberg (1936) was 5.0°C between 1929 and 1933, and the average annual variation was 1.7°C. Thus the diel temperature range observed at the head of the canyon (Tables 1 and 2) is about the same as the mean annual range in the southern bay waters.

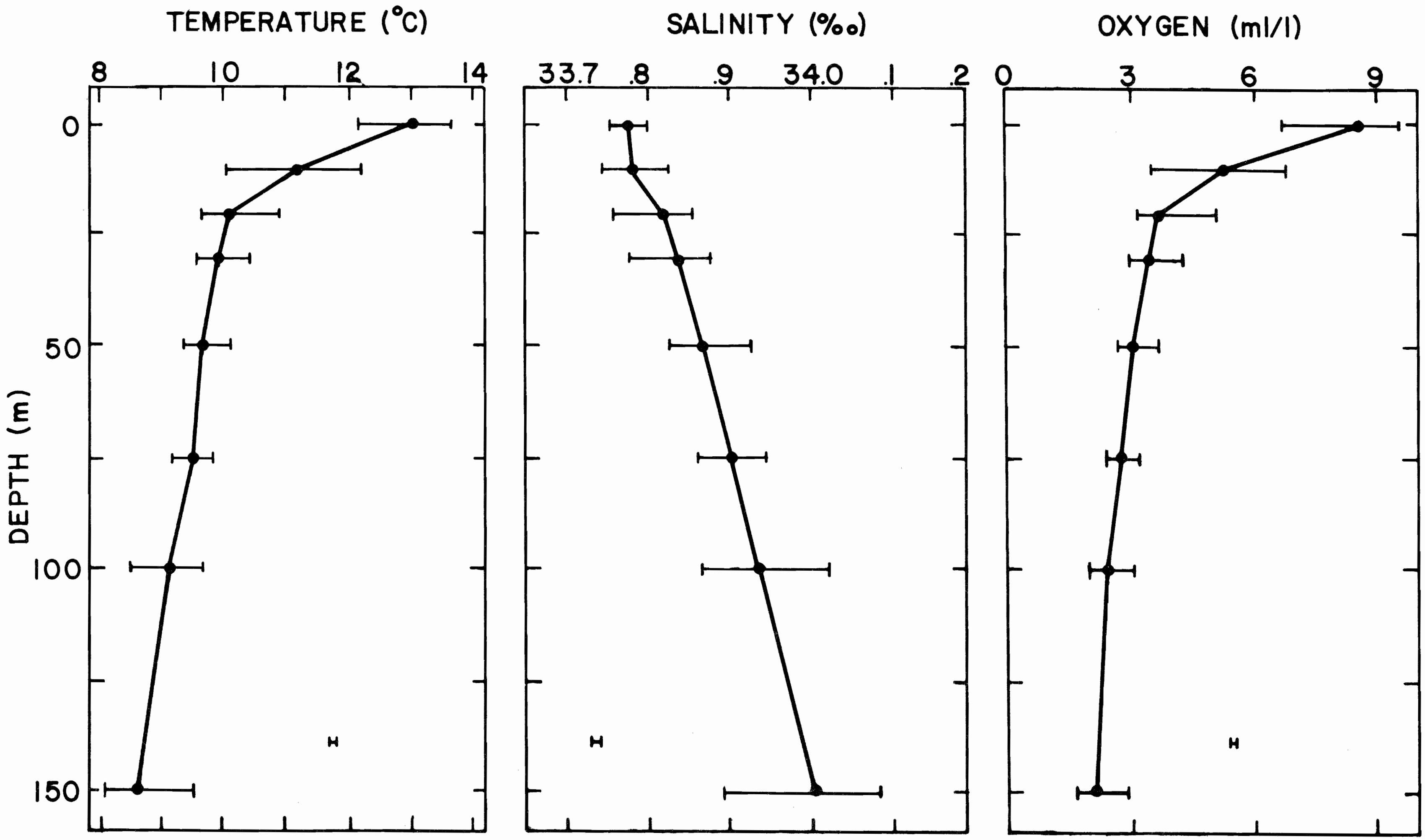

Figure 4. Time mean vertical distributions and observed ranges of temperature (°C), salinity (°/oo), and dissolved oxygen (ml/liter) at station 1108, 7-8 August 1971. Small bars represent the analytical precision (2 SD).

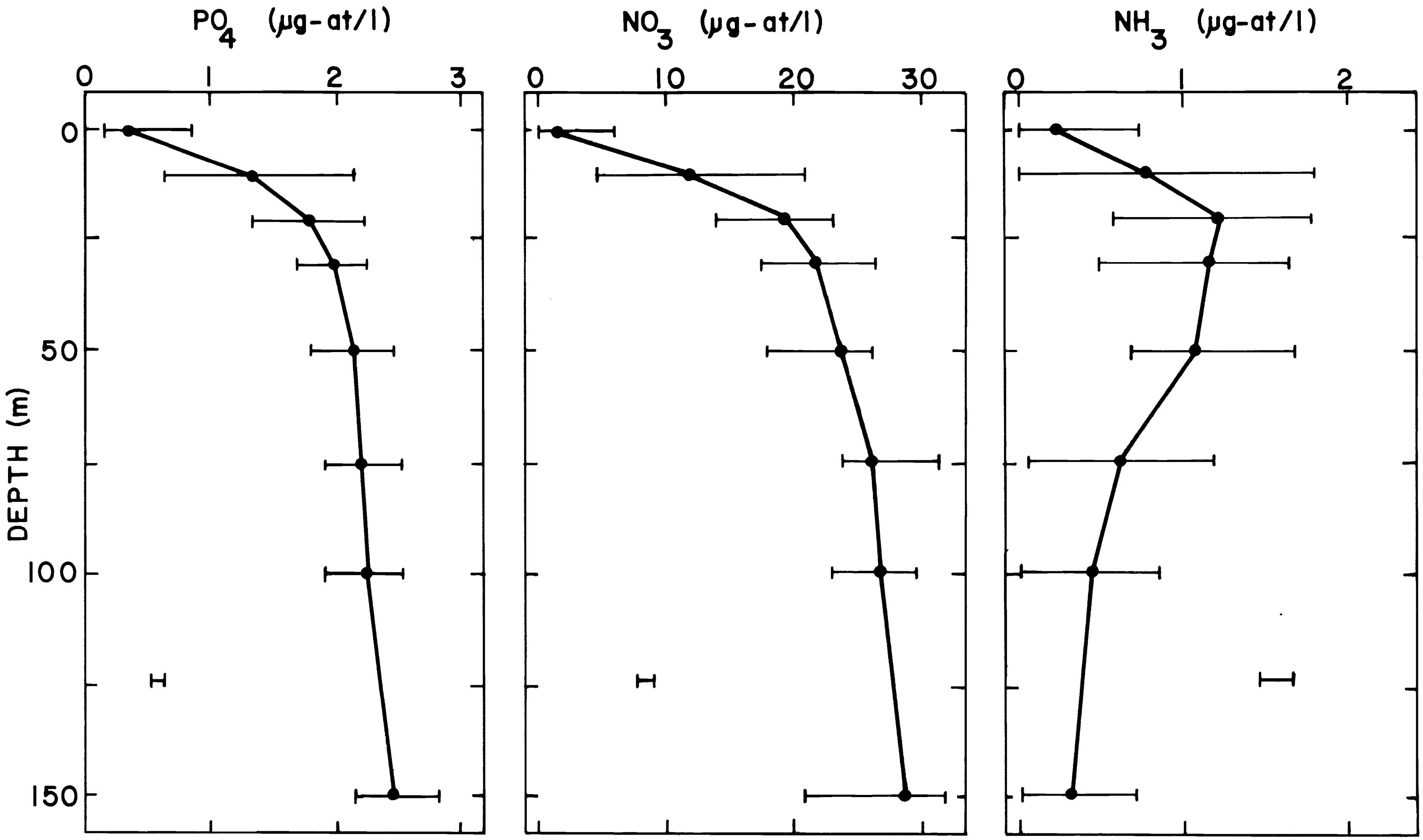

Figure 5. Time mean vertical distributions and observed ranges of dissolved phosphate-phosphorus, nitrate-nitrogen, and ammonia-nitrogen (ug-atoms/liter) at station 1108, 7-8 August 1971. Small bars represent the analytical precision (2 SD).

Table 3. Range of 0-10 m average values between February 1971 and May 1972 in Monterey Submarine Canyon (W. Smethie, personal communication)

Temperature	9.8 -16.3
Salinity, $^{o}/oo$	33.20-33.97
Phosphate, µg-atoms/liter	0.3 - 1.7
Nitrate, µg-atoms/liter	0 - 20
Ammonia, µg-atoms/liter	0 - 1.5

Early investigators in Monterey Bay (Bigelow and Leslie 1930, Skogsberg 1936) were aware of the dynamic nature of circulation in the bay, and reported that its waters could be exchanged completely in a few days. They did not recognize however, that tidal effects in Monterey Submarine Canyon were as large as reported here. Skogsberg (1936), for example, reported that "tidal oscillations in Monterey Bay were of such a minor amplitude that they could not have affected our thermal records to an appreciable extent". These conclusions were based upon data obtained primarily in southern Monterey Bay, in areas not strongly influenced by the canyon. From continuity requirements estimates can be made of the mean lateral current velocities across the canyon edge and down the canyon axis during a flooding tide on 7-8 August 1971. These calculations show that even for large tidal fluctuations at the head of the canyon, the effects are probably limited to a relatively small area near the canyon, and they do not contradict Skogsberg's conclusions.

Between 1800, 7 August and 0200, 8 August the vertical spacing of the 25.8 and 26.2 σ_T surfaces diverged by about 65 m at station 1103 (Fig. 2), whereas between 1400 and 2400, 7 August these surfaces diverged by about 115 m at station 1108 (Fig. 3). This was probably caused by the lateral convergence of water from over the shelf north and south of the canyon during the period of falling tide.

Between station 1103 and the head of the canyon (where the canyon is about 900 m long, 500 m wide, and 100 m deep) the 65 m increase in the isopycnal spacing required a convergence of about 30 x 10^6 m^3. Between stations 1108 and 1103 (where the canyon dimensions are 3000 m long, 2000 m wide, 150 m deep) the 115 m increase in spacing required a convergence of about 700 x 10^6 m^3. If it is assumed that water of σ_T = 26 entered the canyon from lateral flow parallel to the isobaths between 10 m (the approximate depth of the 25.8 σ_T surface) and the bottom (about 20 m between station 1103 and shore, and 40 m between stations 1108 and 1103); then average lateral velocities across the edge of the canyon would have been about 5 cm/sec in the nearshore region and 9 cm/sec between stations 1108 and 1103 (Fig. 6). The resultant down-canyon velocity past station 1103 would have been about 3 cm/sec for a flow over a depth range of 50 m, and that at station 1108 over a depth range of about 75 m would have been 13 cm/sec. The volume of water entering the canyon on the observed tide would have covered an area of 25 km^2 over a depth of 25 m on the shelf near the head of the canyon (Fig. 6).

These computed velocities agree well with the current meter observation of Gatje and Pizinger (1965), Dooley (1968), Njus (1968), and Caster (1969), who found mean up- and down-canyon speeds of about 10 cm/sec. Moreover the present observations show that this effect occurs throughout a large part of the water column. The tidal flow

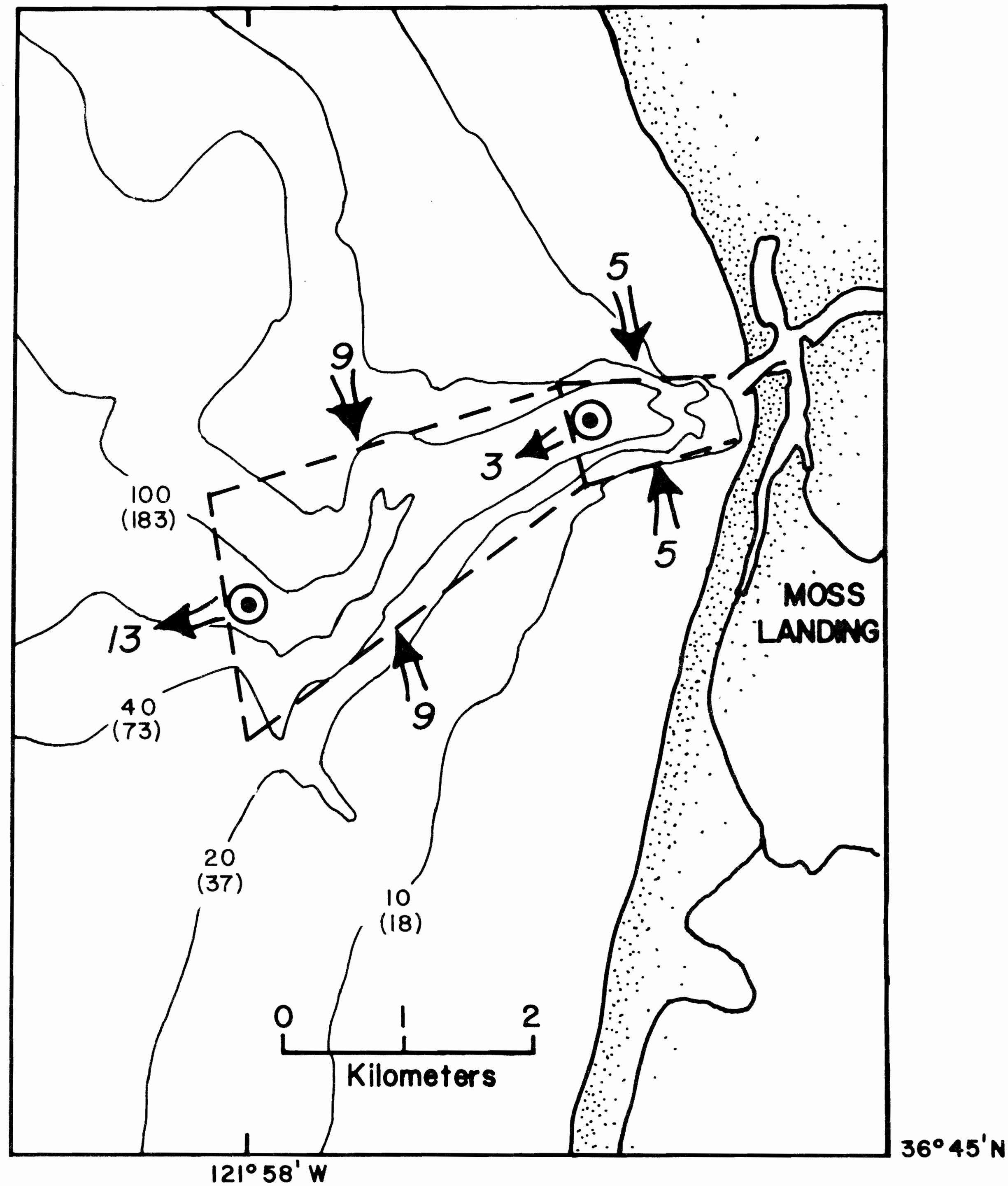

Figure 6. Study area at the head of Monterey Submarine Canyon. Numbers beside the arrows represent the inferred flood tide velocities (cm/sec) computed from the model presented in the text. Depth contours in fathoms and (meters).

would produce an area of relatively cool, nutrient-rich water over the canyon. Thus even during non-upwelling periods, it would be possible to observe surface effects similar to those caused by wind-induced upwelling.

Schultz (1971) observed another surface effect presumably caused by the tidal convergence. Frequently during periods of rising tide and small sea states, the authors have observed a surface slick lying parallel to the 10 fm isobath on the south edge of Monterey Submarine Canyon. During current measurements using 2.5 m long drift poles, Schultz observed 4 poles initially set on a line with 100 m spacing to converge in a 100 m^2 area in the slick just south of station 1103. This observation, made during a flooding tide, indicates that even very near-surface water enters into the up- and down-canyon flow.

The above results demonstrate some of the difficulties in interpreting hydrographic and biological data obtained by conventional sampling methods in nearshore areas having large bathymetric relief. Moreover, the tidal oscillations in Monterey Submarine Canyon provide a flushing mechanism that is presumably independent of the wind field and offshore current regime, both of which may vary sporadically, and cause difficulty in understanding and predicting the general circulation of Monterey Bay. Near the head of Monterey Submarine Canyon, and perhaps in its tributary canyons, a predictable periodic exchange of deep water occurs. This exchange mechanism should be studied in greater detail to determine its role in flushing Monterey Bay and to determine if the tidal flushing has potential application in dispersing industrial or domestic wastes.

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APPENDIX: HYDROGRAPHIC AND CHEMICAL DATA, ML CRUISE 14, 7-8 AUGUST 1971

Explanation of Tables

CRUISE	Moss Landing Marine Laboratories consecutive hydrographic cruise number.
STATION	Permanent hydrographic station number. 11 designates Moss Landing Marine Laboratory.
DATE	Local date of sampling.
HOUR	Local sampling time (Pacific Daylight Savings Time +7). Time of messenger release is given for one-cast stations, median time on station is given for multi-cast stations. For two-cast (8 bottle) stations the time on-station was generally under one hour.
N LATITUDE W LONGITUDE	Observed station position corresponding to sampling time given above. Drift while on station was generally less than 0.5 miles. When greater drift was experienced, the ship was brought back to the station for subsequent casts.
TRANSP	Secchi disk depth, meters.
WAVES	
dir	Direction from which the dominant waves are coming, in tens of degrees, according to WMO Code 0885.
ht	Height of dominant waves according to WMO Code 1555.
p	Period of dominant waves according to WMO Code 3155.
WIND	
dir	Direction from which the wind is blowing, in tens of degrees, according to WMO Code 0877.
speed	Wind speed in knots.
BAROM	Pressure in millibars.
AIR TEMP ^{o}C	
dry	Air temperatures were obtained about 2 m above sea surface. Dry-bulb air temperature in degrees centigrade.

wet	Wet-bulb air temperature in degrees centigrade.
WEATH	Present weather according to WMO Code 4677.
CLOUDS	
typ	Cloud type according to WMO Code 0500.
amt	Cloud amount in eights according to WMO Code 2700.
VISIB	Sea level visibility according to WMO Code 4300.
DEPTH	Accepted depth in meters from which the sample was obtained, determined from wire length, wire angle, and thermometric depth calculation.
TEMP	*In situ* water temperature in degrees centigrade.
SALINITY	Salinity in grams/kilogram (^{o}/oo or ppt).
SIGMA T	Potential density anomaly, computed from the equations in Knudsen's Hydrographical Tables (Knudsen, 1901).
OXYGEN	Dissolved oxygen concentration in ml(STP)/liter.
AOU	Apparent oxygen utilization in μg-atoms O_2-O/liter: the difference between the observed oxygen concentration and the oxygen solubility computed from the *in situ* temperature and salinity using the equations of Truesdale, *et al*, (1955).
PHOSPHATE	Concentration of reactive phosphate in μg-atoms PO_4-P/liter.
NITRATE	Concentration of dissolved nitrate in μg-atoms NO_3-N/liter.
NITRITE	Concentration of dissolved nitrite in μg-atoms NO_2-N/liter.
AMMONIA	Concentration of dissolved ammonia in μg-atoms NH_3-N/liter.
SILICA	Concentration of reactive silica in μg-atoms SiO_2-Si/liter.
*	Questionable data point. These values are suspect based upon preliminary analysis of the data and should be used with caution.

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-1	7 AUG 1971	7.5	36° 48.1'	121° 48.2'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
3	28	0	2			1012.5	10.8	10.8	45		9	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	12.74	33.752	25.50	6.44	-55	111	.97	5.6	.16	.33	7
5	10.78	33.791	25.89	4.84	110	80	1.66	15.8	.36	.78	13
10	10.16	33.824	26.03	3.83	207	62	2.17	20.7	.53	1.01	20
20	9.80	33.857	26.11	3.40	250	55	2.33	22.6	.58	1.08	25
30	9.71	33.885	26.15	3.20	269	52	2.40	25.1	.46	.94	26
50	8.99	33.977	26.34	2.41	348	38	2.64	28.1	.34	.41	35
75	8.48	34.034	26.46	2.02	390	32	2.77	31.7	.29	.24	41
100	8.37	34.049	26.49	1.91	401	30	2.87	32.7	.32	.48	44

CAST 1: 30 to 100 m; 0658 mess. time; 0° wire angle
CAST 2: 0 to 20 m; 0730 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-2	7 AUG 1971	10.9	36° 48.1'	121° 48.2'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
3	27	0	2			1012.5	11.9	11.7	45		9	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.28	33.750	25.39	7.37	-144	128	.50	2.1	.12	.00	1
5	11.78	33.785	25.71	7.31	-122	123	.69	2.4	.25	.09	6
10	10.65*	33.813	25.93	4.83	112	79	1.71	15.3	.48	.52	15
20	9.86	33.855	26.10	3.49	241	56	2.20	23.0	.63	.75	25
30	9.84	33.862	26.11	3.35	254	54	2.36	23.1	.67	.88	28
50	9.67	33.890	26.16	3.14	275	51	2.44	25.8	.71	.74	29
75	9.37	33.920	26.23	2.84	305	45	2.57	27.6	.63	.86	32
100	9.24	33.945	26.27	2.70	319	43	2.62	27.0	.53	.58	33

* indicates questionable data: paired thermometer read 10.71

CAST 1: 30 to 100 m; 1022 mess. time; 0° wire angle

CAST 2: 0 to 20 m; 1053 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-3	7 AUG 1971	13.2	36° 48.1'	121° 48.2'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
3	27	0	2	28	4	1012.2	14.4	13.9	42			7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/1	AOU ug-at/1	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.74	33.726	25.28	8.60	-258	151	.25	1.0	.03	.56	3
5	11.39	33.766	25.76	5.89	9	98	1.03	9.5	.28	.69	11
10	10.88*	33.778	25.87	5.45	54	90	1.25	11.9	.34	1.32	13
20	10.46	33.821	25.97	4.20	171	69	1.76	17.4	.47	1.73	22
30	10.47	33.787	25.95	4.30	162	70	1.72	17.8	.41	2.20	20
49	10.12	33.825	26.04	3.83	208	62	1.91	19.9	.48	1.94	23
74	9.82	33.843	26.10	3.43	247	55	2.09	21.5	.53	1.77	28

* indicates questionable data: paired thermometer read 10.94

CAST 1: 30 to 74 m; 1242 mess. time; 10° wire angle

CAST 2: 0 to 20 m; 1312 mess. time; 7° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-4	7 AUG 1971	15.4	36° 48.1'	121° 48.2'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
3	28	1	2	27	6	1012.5	14.4	13.9	44			6

DEPTH	TEMP	SALINITY	SIGMA T	OXYGEN	AOU	SAT	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
m	°C	ppt		ml/1	ug-at/1	%	ug-atoms/liter				
0	14.04	33.724	25.21	8.78	-277	155	.28	.9	.10	.38	1
5	10.85	33.758	25.86	4.92	102	81	1.48	14.3	.43	1.18	14
10	10.28	33.780	25.97	4.20	173	68	1.78	18.2	.50	1.61	18
20	9.86	33.837	26.09	3.43	247	55	2.02	21.8	.58	1.61	26
30	9.85	33.846	26.10	3.33	256	54	2.13	22.0	.64	1.72	29
49	9.78	33.856	26.12	3.26	263	53	2.17	22.9	.59	1.52	31
74	9.24	33.917	26.25	2.65	324	42	2.33	25.6	.55	1.49	33
99	8.88	33.969	26.35	2.34	356	37	2.47	27.6	.48	.87	38

CAST 1: 30 to 99 m; 1450 mess. time; 9° wire angle
CAST 2: 0 to 20 m; 1522 mess. time; 8° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-5	7 AUG 1971	17.4	36° 48.1'	121° 48.2'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
3	27	1	2	27	6	1010.8	14.7	14.2	2		1	7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	14.40	33.721	25.14	9.01	-302	160	.25	.9	.07	.00	4
5	11.50	33.782	25.76	6.97	-88	117	.84	7.5	.26	.31	9
10	9.64	33.876	26.16	3.25	265	52	2.19	23.1	.58	1.76	31
20	9.40	33.905	26.22	2.93*	297	47	2.26	25.0	.58	1.03	35
30	9.71	33.866	26.14	3.16	273	51	2.15	22.1	1.23	1.78	33
50	8.82	33.983	26.37	2.27	363	36	2.46	28.3	.43	.42	45
75	8.42	34.029	26.47	1.96	396	31	2.58	30.3	.36	.17	48
100	8.38	34.044	26.49	1.87	404	29	2.63	30.4	.32	.03	49

* indicates questionable data: oxygen appears anomalously low

CAST 1: 30 to 100 m; 1659 mess. time; 3° wire angle
CAST 2: 0 to 20 m; 1724 mess. time; 8° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-6	7 AUG 1971	20.9	36° 48.1'	121° 48.2'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
	29	1	2	23	6	1010.5	14.4	13.9	2		2	8

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.88	33.740	25.26	9.00	-296	158	.39	1.0	.22	.00	5
5	13.42	33.748	25.36	7.87	-190	137	.60	2.7	.18	.00	9
10	11.97*	33.784	25.67	6.34	-37	107	1.01	7.1	.31	.00	15
20	10.79	33.804	25.90	4.88	106	80	1.51	14.3	.45	.48	21
27	10.23	33.821	26.01	3.85	205	63					
45	9.84	33.861	26.11	3.25	263	52	2.16	22.9	.60	1.13	36
67	9.04	33.958	26.32	2.41	348	38	2.41	27.1	.51	.64	45
89	8.91	33.972	26.35	2.31	358	37	2.49	27.6	.48	.66	45

* indicates questionable data: paired thermometer read 12.07

CAST 1: 27 to 89 m; 2015 mess. time; 27° wire angle

CAST 2: 0 to 20 m; 2055 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-7	7 AUG 1971	24.0	36° 48.1'	121° 48.2'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
	26	1	2	14	2	1011.5	13.9	13.6	2			7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.28	33.761	25.40	8.77	-269	152	.22	1.2	.05	.14	1
5	12.74	33.765	25.51	8.49	-238	146	.30	1.1	.06	1.09	6
10	12.22*	33.768	25.61	7.99	-188	136	.36		.06	1.09	2
20	10.60	33.773	25.91	4.62	132	76	1.45	13.8	.39	2.21	17
30	10.76	33.790	25.90	4.81	113	79	1.46	14.8	.40	1.60	19
50	10.62	33.803	25.93	4.38	153	72	1.63	16.8	.44	.99	23
75	10.09	33.832	26.05	3.80	211	62	1.85	22.9	.51	1.08	28
100	9.47	33.896	26.20	2.91	298	47	2.21	30.3	.56	.82	37

* indicates questionable data: paired thermometer read 12.29

CAST 1: 30 to 100 m; 2333 mess. time; 0° wire angle

CAST 2: 0 to 20 m; 0004 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-8	8 AUG 1971	2.6	36° 48.1'	121° 48.2'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
	28	1	2	29	2	1010.5	13.9	13.6	1			7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/1	AOU ug-at/1	SAT %	PHOSPHATE ug-atoms/liter	NITRATE	NITRITE	AMMONIA	SILICA
0	12.70	33.749	25.50	6.48	-58	111	.88	9.6	.27	.69	10
5	11.85	33.784	25.69	6.15	-19	104	.87	12.7	.26	.48	9
10	10.86*	33.795	25.88	5.14	82	85	1.38	14.8	.42	.84	14
20	10.56	33.795	25.94	4.55	138	75	1.58	18.1	.46	1.16	20
30	10.59	33.794	25.93	4.64	130	76	1.67	19.2	.48	.99	19
50	10.26	33.824	26.01	3.94	196	64	1.72	19.8	.47	1.66	22
75	9.93	33.851	26.09	2.71	310	44	1.87	19.0	.48	1.20	25
100	9.72	33.874	26.14	3.25	264	52	2.04	21.2	.53	.90	30

* indicates questionable data: paired thermometer read 10.92

CAST 1: 30 to 100 m; 0202 mess. time; 0° wire angle

CAST 2: 0 to 20 m; 0236 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-9	8 AUG 1971	4.9	36° 48.1'	121° 48.2'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
	28	1	2	14	2	1010.8	13.3	12.8	2			7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE ug-atoms/liter	NITRATE ug-atoms/liter	NITRITE ug-atoms/liter	AMMONIA ug-atoms/liter	SILICA ug-atoms/liter
0	11.92	33.761	25.66	3.69	199	62	1.21	11.9	.30	1.14	19
5	10.69	33.800	25.92	4.55	137	75	1.37	15.4	.43	1.63	23
10	10.32	33.796	25.98	4.19	173	68	1.52	18.6	.38	1.87	26
20	9.94	33.838	26.08	3.58	232	58	1.54	17.5	.40	1.48	33
30	10.01	33.838	26.06	3.55	234	58	1.78	21.8	.37	1.72	29
50	9.84	33.854	26.11	3.28	260	53	1.87	23.6	.36	1.57	33
75	9.60	33.881	26.17	3.07	282	49	1.93	23.8	.40	1.26	36
100	9.56	33.890	26.18	2.95	293	47	1.94	24.5	.44	1.41	38

CAST 1: 30 to 100 m; 0422 mess. time; 5° wire angle
CAST 2: 0 to 20 m; 0454 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1103-10	8 AUG 1971	7.2	36° 48.1'	121° 48.2'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
2	29	1	2	10	3	1012.5	13.4	13.2	2		2	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.64	33.736	25.31	6.06	-31	106	.78	3.7	.33	.58	11
5	10.02	33.847	26.07	3.50	238	57	1.67	17.9	.63	1.61	27
10	9.82	33.851	26.11	3.42	248	55	1.67	18.4	.55	1.12	28
20	9.74	33.863	26.13	3.29	261	53	1.91	22.4	.72	1.36	33
30	9.79	33.867	26.12	3.25	264	52	1.88	22.6	.57	1.18	33
50	9.73	33.881	26.14	3.15	273	51	1.78	21.3	.60	1.26	32
74	8.96	33.967	26.34	2.38	351	38	2.01	24.7	.46	1.05	41
99	8.48	34.045	26.47	1.93	398	30	2.31	33.7	.40	.49	53

CAST 1: 30 to 99 m; 0636 mess. time; 8° wire angle
CAST 2: 0 to 20 m; 0710 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-1	7 AUG 1971	8.8	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
4	28	0	2			1012.5	10.0	10.0	45	X	9	6

DEPTH	TEMP	SALINITY	SIGMA T	OXYGEN	AOU	SAT	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
m	°C	ppt		ml/l	ug-at/l	%	ug-atoms/liter				
0	12.18	33.754	25.61	6.65	-67	113	.86	5.8	.25	.36	5
10	11.00	33.785	25.85	4.76	114	79	1.69	15.5	.45	1.39	16
20	10.30	33.803	25.99	4.13	179	67	1.95	19.5	.53	.91	18
30	10.23	33.811	26.01	4.05	187	66	2.01	19.2	.55	1.01	18
50	9.72	33.856	26.13	3.19	270	51	2.42	24.2	.60	.79	29
75	9.68	33.876	26.15	3.08	280	50	2.49	25.4	.68	.82	28
100	9.46	33.902	26.21	2.89	300	46	2.45	26.4	.74	.14	27
150	9.13	33.950	26.30	2.55	334	41	2.85	20.8	.57	.49	17

CAST 1: 50 to 150 m; 0812 mess. time; 4° wire angle
CAST 2: 0 to 30 m; 0840 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-2	7 AUG 1971	12.0	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
4	27	0	2	27	6	1012.5	12.5	12.2	43	X	9	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/1	AOU ug-at/1	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	12.74	33.760	25.50	8.61	-249	148	.31	1.7	.10	.09	2
10	10.24	33.802	26.00	3.87	203	63	2.12	20.5	.61	.89	21
20	9.92	33.828	26.07	3.53	237	57	2.29	23.1	.65	1.09	25
30	9.70	33.855	26.13	3.20	269	51	2.15	22.6	.47	4.59	30
48	9.77	33.856	26.12	3.23	266	52	2.41	23.9	.64	.98	27
72	9.70	33.863	26.14	3.14	274	51	2.45	23.9	.62	.85	30
96	9.56	33.887	26.18	2.97	291	48	2.48	25.7	.70	.55	29
144	9.34	33.922	26.24	2.71	317	43	2.54	28.2	.69	.31	31

CAST 1: 48 to 144 m; 1128 mess. time; 16° wire angle
CAST 2: 0 to 30 m; 1200 mess. time; 10° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-3	7 AUG 1971	14.3	36° 47.4'	121° 50.0'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
4	28	1	2	28	8	1012.5	13.9	13.9	47	X	9	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.23	33.792	25.43	9.08	-296	158	.20	.3	.10	.73	2
10	9.96	33.823	26.06	3.56	234	58	1.95	20.9	.52	1.78	28
20	9.68	33.852	26.13	3.22	268	52	2.12	22.8	.58	1.69	46
30	9.60	33.878	26.16	3.06	283	49	2.17	23.1	.62	1.47	31
49	9.40	33.927	26.23	2.68	319	43	2.23	25.8	.59	.76	31
73	9.28	33.943	26.27	2.67	321	43	2.30	25.7	.53	1.15	35
98	8.95	33.974	26.34	2.44	346	39	2.42	27.5	.47	.71	38
147	8.65	34.014	26.42	2.09	381	33	2.49	29.3	.38	.63	46

CAST 1: 49 to 147 m; 1339 mess. time; 12° wire angle
CAST 2: 0 to 30 m; 1418 mess. time; 8° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-4	7 AUG 1971	16.4	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
3	27	1	2	27	4	1012.5	14.4	13.9	42	0	1	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.52	33.783	25.37	9.31	-320	163	.23	.8	.07	.22	1
10	10.96	33.770	25.85	4.83	109	80	1.52	14.8	.40	1.02	15
20	9.69	33.842	26.12	3.27	263	53	1.72	16.9	.38	1.57	19
30	9.59	33.865	26.16	3.07	282	49	2.21	23.4	.58	1.47	29
50	9.42	33.856	26.18	2.79	309	45	2.19	25.8	.69	.82	29
74	9.16	33.939	26.28	2.47	341	39	2.37	27.1	.52	.66	34
99	8.50	34.022	26.45	2.00	391	31	2.58	29.7	.35	.52	41
149	8.10	34.081	26.56	1.66	427	26	2.72	31.6	.25	.22	48

CAST 1: 50 to 149 m; 1553 mess. time; 7° wire angle
CAST 2: 0 to 30 m; 1622 mess. time; 11° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-5	7 AUG 1971	18.6	36° 47.4'	121° 50.0'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
4	27	1	2	21	6	1010.2	15.6	14.4	2	0	1	7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE ug-atoms/liter	NITRATE	NITRITE	AMMONIA	SILICA
0	13.28	33.784	25.42	9.27	-313	161	.20	.1	.03	.07	3
10	11.68	33.765	25.71	6.75	-71	113	.71	4.8	.20	.00	8
20	10.89	33.757	25.85	5.09	86	84	1.37	13.9	.40	.53	14
30	10.40	33.777	25.95	4.30	163	70	1.68	17.6	.47	.94	22
50	9.62	33.885	26.17	3.02	286	49	2.20	24.6	.69	.68	32
75	9.45	33.912	26.21	2.79	309	45	2.24	26.4	.67	.13	34
100	9.21	33.928	26.27	2.59	330	41	2.33	27.0	.47	.25	37
149	8.25	34.048	26.51	1.88	405	29	2.70	30.8	.34	.00	47

* indicates questionable data: Paired thermometer read 10.95

CAST 1: 50 to 149 m; 1803 mess. time; 5° wire angle
CAST 2: 0 to 30 m; 1835 mess. time; 7° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-6	7 AUG 1971	23.0	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
	26	1	2	14	5	1011.2	13.9	13.3	2			7

DEPTH	TEMP	SALINITY	SIGMA T	OXYGEN	AOU	SAT	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
m	°C	ppt		ml/l	ug-at/l	%	ug-atoms/liter				
0	13.28	33.789	25.42	9.23	-310	160	.22	.5	.04	.00	4
10	11.19*	33.779	25.81	5.48	48	91	1.24	10.6	.30	.68	15
20	10.09	33.809	26.03	3.74	216	61	1.81	17.3	.45	1.53	25
30	10.01	33.821	26.00	3.76	215	61	1.89	17.9	.50	1.20	28
48	10.06	33.826	26.05	3.66	224	59	1.82	17.7	.51	1.43	28
71	10.00	33.834	26.06	3.56	233	58	2.03	21.0	.59	1.40	30
95	9.66	33.859	26.14	3.19	271	51	2.19	22.4	.61	.95	35
143	9.30	33.923	26.25	2.75	314	44	2.20	22.9	.52	.21	36

* indicates questionable data: Paired thermometer read 11.25
CAST 1: 48 to 143 m; 2203 mess. time; 18° wire angle
CAST 2: 0 to 30 m; 2258 mess. time; 6° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-7	8 AUG 1971	1.4	36° 47.4'	121° 50.0'

TRANSP m	WAVES dir	ht	p	WIND dir	speed	BAROM mb	AIR TEMP °C dry	wet	WEATH	CLOUDS typ	amt	VISIB
	29	1	2	11	0	1010.8	13.9	13.3	1			7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE ug-atoms/liter	NITRATE	NITRITE	AMMONIA	SILICA
0	12.54	33.776	25.56	8.12	-203	139	.32	.4	.07	.00	13
10	11.28	33.780	25.80	5.34	59	89	1.12	10.2	.27	.59	12
20	10.18	33.789	26.00	3.51	236	57	1.81	23.1	.52	1.06	23
30	10.02	33.812	26.04	3.66	224	59	1.87	26.3	.52	.91	26
50	9.82	33.833	26.09	3.32	257	54	2.06	26.1	.55	1.67	30
75	9.76	33.848	26.11	3.19	269	51	2.09	31.4	.60	1.07	31
100	9.62	33.863	26.15	3.04	284	49	2.16	24.0	.60	.72	32
150	9.50	33.892	26.19	2.91	297	47	2.17	28.4	.65	.68	33

CAST 1: 50 to 150 m; 0042 mess. time; 0° wire angle
CAST 2: 0 to 30 m; 0124 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-8	8 AUG 1971	3.8	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
	29	1	2	26	1	1011.2	13.6	13.1	1			7

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	13.10	33.774	25.44	8.73	-263	151	.20	.7	.04	.00	1
10	11.14	33.746	25.79	5.28	66	88	1.16	11.2	.30	.13	10
20	9.70	33.848	26.12	3.23	267	52	1.97	21.5	.55	.57	29
30	9.66	33.851	26.13	3.13	276	50	2.11	22.9	.54	.48	33
50	9.62	33.888	26.17	2.91	296	47	2.16	25.2	.49	1.08	32
75	9.53	33.901	26.19	2.81	306	45	2.14	25.1	.64	.00	31
100	9.36	33.914	26.23	2.62	325	42	2.23	29.3	.63	.00	34
150	9.02	33.965	26.33	2.48	342	39	2.37	30.9	.50	.00	40

CAST 1: 50 to 150 m; 0312 mess. time; 0° wire angle
CAST 2: 0 to 30 m; 0350 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-9	8 AUG 1971	6.1	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
	32	1	2	8	3	1011.5	13.3	12.8	2		2	7

DEPTH	TEMP	SALINITY	SIGMA T	OXYGEN	AOU	SAT	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
m	°C	ppt		ml/l	ug-at/l	%	ug-atoms/liter				
0	13.57	33.756	25.33	8.80	-274	154	.14	.3	.02	.26	4
10	11.63	33.777	25.73	6.69	-65	112	.60	4.8	.09	.60	6
20	9.80	33.846	26.11	3.25	263	52	1.83	20.9	.55	1.73	34
30	9.70	33.861	26.13	3.22	267	52	1.91	22.1	.60	1.36	38
50	9.63	33.875	26.16	2.97	291	48	1.81	21.4	.50	1.06	34
75	9.39	33.925	26.23	2.53	333	40	1.89	24.6	.47	.17	37
100	8.94	33.975	26.35	2.28	361	36	1.91	22.9	.29	.33	38
150	8.22	34.074	26.53	1.75	417	27	2.33	29.7	.19	.29	52

CAST 1: 50 to 150 m; 0531 mess. time; 0° wire angle
CAST 2: 0 to 30 m; 0604 mess. time; 0° wire angle

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 14	1108-10	8 AUG 1971	8.2	36° 47.4'	121° 50.0'

TRANSP	WAVES			WIND		BAROM	AIR TEMP °C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
4	29	1	2	14	4	1012.2	14.4	13.3	2		1	6

DEPTH m	TEMP °C	SALINITY ppt	SIGMA T	OXYGEN ml/l	AOU ug-at/l	SAT %	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA
							ug-atoms/liter				
0	12.86	33.782	25.50	8.69	-257	150	.12	1.5	.08	.15	3
10	12.14	33.776	25.63	6.38	-43	108	.68	6.2	.28	.54	9
20	10.46	33.813	25.97	4.29	163	70	1.49	18.4	.56	1.41	24
30	10.02	33.830	26.06	3.64	226	59	1.76	21.7	.66	1.61	31
50	9.69	33.871	26.14	3.05	283	49	1.97	24.3	.77	1.36	36
75	9.52	33.904	26.20	2.78	309	45	1.99	26.2	.71	.41	36
100	9.25	33.931	26.26	2.50	337	40	2.07	27.4	.66	.87	38
150	8.57	34.027	26.44	1.99	391	31	2.26	29.1	.43	.13	49

CAST 1: 50 to 150 m; 0737 mess. time; 0° wire angle
CAST 2: 0 to 30 m; 0809 mess. time; 2° wire angle